Wayne State University

Muon Flux vs. Electric field

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The purpose of this experiment is to determine whether or not an electric field will have an effect on the travel of muons. We attached two metal plates on each side of one of the muon detection apparatuses or "paddles" and added an electric charge. We then ran many flux tests in order to determine if the average flux reading would change. Once we got the results, it turns out that the muons are somehow affected by the electric field. We concluded that this was because of the fact that the electrons and protons produced in the electric field inelastically collide with the muons as they travel through the plates. These results showed that after a certain voltage (namely 50 volts), the number of muon detected seemed to level out, meaning that no matter how much higher the voltage was, after that point, the muons were not affected anymore. This means that larger projects including the LHC may not need such a large amount of power if they wish to effect muons.

Does Direction Affect Muon Flux?

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We are trying to determine from which direction most cosmic rays tend to enter the earth's atmosphere. With this knowledge, scientists can find the location with the highest muon flux, allowing them to study muons in larger quantities and intensities. We created a structure to incline our paddles at a consistent angle for each test, collecting muons approaching from each cardinal direction. With our detectors set to three-fold coincidence, we could reasonably infer that each hit reflected a single muon coming from that particular direction. Average flux values for each direction were (events/m^2/min): west, 330.6815; south, 325.8484; north, 301.4036; east, 348.6553. Since the average flux from both east and west is higher than that from north and south, we can reasonably infer that the flux from east and west is higher than that from north and south, relative to our location. This is consistent with what would be expected because of the earth's magnetic field. However, we need to consider that the validity of this claim can be discounted because of experimental error (each of these values is +/- about 22 events/m^2/min). We detected a greater muon flux from the east than from the west. The east-west effect, a consequence of the earth's magnetic field, led us to expect the opposite. However, experimental error can account for this discrepancy, and can even discount any detected east-west asymmetry. We also need to consider that we are located in the western hemisphere, and since east and west directions are relative, our data for those directions does not accurately affect a pattern affecting the entire world, but merely a pattern for our location; we only detected muons from rays that were deflected to the west. To accurately study the expected consequences of the earth's magnetic field, such as the east-west effect, it is necessary to set up detectors in different locations. More accurate results could be obtained by comparing data from detectors placed on four corners of the earth. To study the east-west effect, data can be compared from two detectors along the equator: one in the middle of the eastern hemisphere and one in the middle of the western hemisphere. To compare muon flux between north and south, detectors can be placed on the north and south poles. If performing a study similar to ours in a single location, we recommend that you perform a control experiment. (We were unable to do this because of inclement weather and time constraints.) This would involve spacing out four detectors with a consistent height between them, parallel to the ground. This can calculate the average muon flux approaching your location at a 90-degree angle, and it can be used as a standard of comparison for your data with the paddles inclined.

Water Temperature Affecting Muon Flux

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The objectives of the study were to determine how water and aluminum foil affect the muon flux that muon counters/detectors obtain. The temperature along with the aluminum foil (whether it covered the bucket or not) was varied in order to determine this relationship. The study was done in the Physics Building (three-story building) on the ground floor of the Wayne State University Campus in Detroit, Michigan. It was done with four total muon counters/detectors, water and aluminum foil. These items were placed consecutively on top of each other (in a stacked pattern: 2 detectors, object, 2 detectors) in order to determine the muon flux of the area at a specific time; the bucket of water was filled to a constant amount and underwent various experiments with and without aluminum covering the top. The results of this investigation were: the colder the water and the presence of aluminum covering the bucket create a lower flux than their opposites. Hotter water and no aluminum covering the bucket create a higher flux than their opposites, too. From the lower flux, there is a 30.75% increase from the hot water (46 °C) with aluminum versus the hot water without aluminum. Also, there is a 32.55% increase from the room temperature water (19 °C) with aluminum versus the room temperature water without aluminum. The significance of these results is to determine the muon flux with various variables being changed at the same time while keeping certain objects at a constant. This can help in the future to understand when and where muon flux is evident the most or the least and how water affects the results. A further study may be done to determine the validity of our results, through a more controlled atmosphere. The experiment may be done without the building, with more water in between the counters/detectors, with an increase of the distance of the muon counters/detectors, and with a constant time of day in which the study is done. These suggestions are to solidify our results in this investigation, and to determine the effectiveness of water and aluminum on muon flux. Also, to see if aluminum foil honestly had an impact in the results if the experiments were run for a longer period of time.

Flux Rate vs. Atmosphere

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The purpose of this experiment was to determine the effect of varying amounts of atmosphere on the flux rate of muons from cosmic rays. To do this, three scintillator detectors were aligned using a frame and angled so that they were detecting muons passing through 30 km, 60 km, and 90 km of atmosphere. The results showed that there is a severe drop in muon flux rate that corresponds with increasing amounts of atmosphere. When one is studying muons, these results mean larger quantities of data will be collected by pointing detectors straight up at the sky (90° to the tangent of the earth).

The Effect of Direction on Muon Flux

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The purpose of this experiment was to determine which direction cosmic rays tend to come in from more: north, south, east, or west. To do this, we ran four studies. Four muon detectors were stacked on a rack and tilted at a 45-degree angle from the ground toward each direction. For each study, we had the rack tilted toward a different direction and ran it for about an hour at a three-fold coincidence. After plotting and analyzing the data, we found that more muons are entering our atmosphere from the northern direction, with a 26.33% higher rate than that of the South. And if compared to the eastern and western direction, the northern and southern directions seemed to receive more hits. These results tell us that although these cosmic rays are coming in from all around, a larger number of them are coming in from the north, possibly as a result of the Earth's magnetic field. With the results found, possible future studies could be conducted to determine as to where exactly from the north these rays are coming from and whether it is actually a result of the magnetic field or not.

Water Level Effect on Muon Flux

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The purpose of this experiment was to determine the effect that water had on the incoming muon particles from cosmic rays. Four CRDs were placed in a telescope-like structure and were placed into pairs. On top there were two detectors; on bottom there were the other two. In between them, several tubs filled with water were placed, and the collective height (depth) of the water was measured out and recorded. Data was collected for two hours for each trial with a coincidence of three to create the telescope. The data concluded that after more water was added, the flux of the detectors would decrease. However, the error bars that were apparent on that data, suggest that the fluxes between different water levels did not change as greatly as just the fixed values show. The results show that water is able to alter the paths of muons, and most likely these muons that are stopped or slowed down are low-energy particles. If we were to further our work, we would increase the depths of the water and get more data to reduce the overall uncertainty.